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Distribution of an endangered burrowing spider *Lycosa ishikariana* in the San'in Coast of Honshu, Japan (Araneae: Lycosidae)

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Abstract — We surveyed habitats of an endangered burrowing wolf spider *Lycosa ishikariana* (Saito 1934) along the San'in coast of Tottori and Shimane Prefectures, southwestern Honshu, Japan. The species was found from eight sites covering seven different beaches from Inasa Beach (Izumo City) in the east to Toda Beach (Masuda City) in the west in Shimane Prefecture for the first time. This extends the southwestern limit of the species' range ca. 160 km westward from the Yumigahama Beach of Tottori Prefecture, the present southernmost record. In the coast of Tottori Prefecture, the species was found from 17 sites that exceed known number of records in the area. The apparent increase of the number of habitats of the species in Tottori Prefecture is probably due to a shift of survey season from the mid summer to June when density of the burrows culminates by the recruit of newly hatched spiderlings. Simple logistic regression analyses suggested that presence/absence of the species is related to any of the sand grain sizes, sorting indices, areas, lengths and maximum widths of the sandy beaches, though a multiple logistic regression analysis revealed that beach areas and sand grain size were the most significant factors. According to the models obtained, requirements for the occurrence of species were estimated to be areas $>$ 0.0313 km^2 (total length $>$ 985 m, width $>$ 60 m) of sandy beach, and sand grain diameter $>$ 0.33 mm.

Key words — Distribution, endangered species, habitats, *Lycosa ishikariana*, sandy beach, San'in Coast

Introduction

Lycosa ishikariana (S. Saito 1934) (Lycosidae) is a huge (larger than 20 mm in body length) fossorial wolf spider that inhabits sandy beaches of Honshu, Hokkaido (Saito 1934; Uyemura 1939; Fujita 1939; Tanaka 1978; Ono & Shinkai 1988; Ono et al. 1991; Nishikawa 2006), Kunashir Island, and Itrup Island (Yuri Marusik pers. comm.), in Japan. Distribution of the species is concentrated on the sandy beaches along the Sea of Japan in Honshu, though a few isolated habitats have been known in a few sandy beaches in Ibaraki Prefecture of the Kanto District (Inoue 1991, 2005; Tokumoto 2005). Sandy beaches suitable for their habitation have been lost by the development, landfill, shore protection work, erosion of sandy beach by the change of the sea current, and frequent intrusion of 4-wheel-drive vehicles on the sandy beach (Tokumoto 2000b, 2004, 2005; Inoue 2005), and by this reason the species is enlisted in the Red List of Japan (Ministry of the Environment of Japan 2000) at the rank of VU (vulnerable) (Nishikawa 2006). The species is also designated as VU in the Red Data Book of Tottori Prefecture (Tsurusaki 2002) that represents the southernmost territory of the species due to a decreasing trend of the species (Fukumoto 1955, 1989). However, no data is available for the current state of the habitats of the species in Tottori Prefecture. Moreover, we have no information whether this species occurs also in Shimane Prefecture which is located in just west of Tottori Prefecture or not, although its occurrence there is expected considering the fact that the species has been known from Yumigahama, the westernmost beach in Tottori Prefecture (Fukumoto 1989; Arita 1993; Tsurusaki 2002). On the other hand, to conserve habitats of this endangered species, it is important to know what environmental factors affect occurrence of the species. Keeping these in mind, we surveyed current distribution of *L. ishikariana* in the San'in Coast of both Shimane and Tottori Prefectures. In this report we present the data for their distribution in the area with results of analyses on the environmental requirements for their occurrence.

Area surveyed and Methods

We surveyed a total of 39 sites in sandy beaches covering almost all the coast of Tottori and Shimane Prefectures for the occurrence of *L. ishikariana* mainly from early to late June in 2005, the season which is suggested to be the best for the survey due to a high density of burrows constructed by newly hatched spiderlings (Tokumoto 2000b, 2004). We walked each sandy beach along the border of coastal vegetation and recorded the sites of burrow nests of the species when they were found using a portable GPS (Garmin eTrex Legend, Garmin International, Inc., Olathe, Kansas). We also mapped burrows for an area of 5 m $\times$ 10 m to calculate

density of the burrows, and measured diameter of each burrow entrance using electric calipers. We also sampled about 50 ml of sands near the burrows to analyze sand grain size.

We performed sand grain analysis using a settling tube according to the formula proposed by Baba & Komar (1981) and calculated median particle diameter, Md_ϕ which represents the diameter corresponding to the 50 % mark on the cumulative curve (ϕ_{50}) as a measure of average size of the sand grains and sorting index σ_I as a measure of uniformity of sorting (Brown & McLachlan 1990). The sorting index represents degree of grain size variation in the sample and when the sand grain variation is low it approaches zero. σ_I is calculated as follows:

$$\sigma_I = (\phi_{84} - \phi_{16})/4 + (\phi_{95} - \phi_5)/6.6.$$

σ_I is rated as follows according to the value: less than 0.35＝excellently sorted / 0.35–0.50＝well sorted / 0.50–0.71＝moderately well sorted / 0.71–1.00＝normally sorted/ 1.00–2.00＝poorly sorted (Folk & Ward 1957).

Length (km), area (km^2), maximum width (＝distance between shoreline and the limit of dunes, m) of each sandy beach were measured and calculated by using 1/25,000 maps issued from the Geographical Survey Institute of Japan.

We analyzed spatial distribution of individuals (＝only burrows with their owner) in each population using Morisita's index I_δ (Morisita 1959; Shimada et al. 2005) when the population contains more than 5 burrows. This index I_δ can be calculated using:

$$I_\delta = n \frac{\sum_{i=1}^{n} x_i(x_i - 1)}{N(N-1)}.$$

where n＝the number of the samples, x_i＝the number of burrows (individuals) in a i-th sample, and N＝total number of burrows (individuals). The I_δ will be 1, larger than 1, and less than 1, when the spatial distribution in a population is random, contagious,and uniform or regular, respectively. The significance of the value was tested by transforming I_δ to F using a formula below and comparing the F value obtained with F-distribution (Rohlf & Sokal 1995):

$$F = \frac{S^2}{\bar{x}} = \frac{I_\delta(N-1) + n - N}{n-1}.$$

The number of samples for the present surveys was 20 (1 m×2 m quadrats for a 5×10 m transect). For surveys periodically made in Tottori Sand Dunes, the number of samples is 16 (3 m×3 m quadrats for a 12×12 m area studied).

To find factors responsible for the occurrence of *L. ishikariana*, we analyzed relationships between presence/absence of spiders and topographical data for beaches. For that purpose, we selected simple and multiple logistic regression analyses (Quinn & Keough 2003) because dependent variable (present/absent of the spiders) is binary. Of the five topographical data (Table 1), three variables concerning magnitude of a beach (length, width, and area) were transformed to logarithmic data (base 10 log) in the statistical analysis, because distributions of these data were highly skewed. All the analyses were conducted with a software JMP (ver. 6.0, SAS Institute 2005).

Results and Discussion

1) Distribution of *Lycosa ishikariana* in the San'in Coast

Results of the survey for a total 39 sites were shown in Table 1 with topographical data of the beaches. Most of the beaches surveyed consist of medium (0.25–0.50 mm in particle diameter) to coarse (0.5 to 1.0 mm) sands. Except for a site in Hôjô Sand Dunes, sorting index showed smaller than 0.5, which means particles are well sorted.

Of the 14 sites surveyed along the coast of Shimane Prefecture, burrows of *L. ishikariana* were found from the following seven sites: 1) Inasa Beach (Shûrimen, Izumo City); 2) Kunibiki Beach: 3) Asari Beach (Hôdengabana, Gôtsu); 4) Okinohama Beach (Ôsakibana, Gôtsu); 5) Iwami Kaihin Park (in front of the Shimane Aquarium "Aquas"); 6) Iwami Kaihin Park Campground; 7) Toda Beach (Masuda) (Fig. 1). Of these sites, Okinohama Beach of Gotsu City is the place where occurrence of *L. ishikariana* was confirmed also on September 20, 1994 (1 juvenile whose body was ca. 10 mm long was collected and numerous small burrows were found) by Susumu Kaneno (S. Kaneno, pers. comm.), though the site located between Tsunozu-cho and Uyagawa-cho is somewhat different from the one (a site adjacent to the Ôsakibana Point) we found. In general, these habitats found in Shimane Prefecture seemed in good conditions, though in a few localities population density of the species was rather low (e.g. two sites in a beach stretching from Izumo City to Koryô-cho and a site in Toda Beach) and the habitats seemed endangered due to extensive bank shore protection work (two sites in Izumo City to Koryô-cho).

On the other hand, of the 25 sites in Tottori Prefecture surveyed during June in 2005, occurrence of burrows of *L. ishikariana* was confirmed in 17 sites (Fig. 2). In Fig. 2, results of the distributional surveys conducted in 1954 (Fukumoto 1955) and in 1988 (Fukumoto 1989) are also shown. Fukumoto (1989) reported that there was a decline in the range occupied by *L. ishikariana* in 1988 compared with the results in 1954 as shown in Fig. 2. However, results of the present survey in 2005 revealed that a number of localities still remain to be preserved. Increase in the number of localities of the species from 1988 to 2005 is likely to be a mere result of the difference in seasons studied by Fukumoto (1989) and the present study. Fukumoto's survey in 1988 was made during a week from 28 July to 3 August, of which finding the spider's burrows is most difficult, whereas our surveys were mainly made in June. Moreover, Fukumoto (1955, 1989) did not present any numerical data on the density of the spiders in both the 1954 and 1988 surveys. Thus, we cannot say anything about increase or decrease of the density of the spiders at each population in Tottori Prefecture.

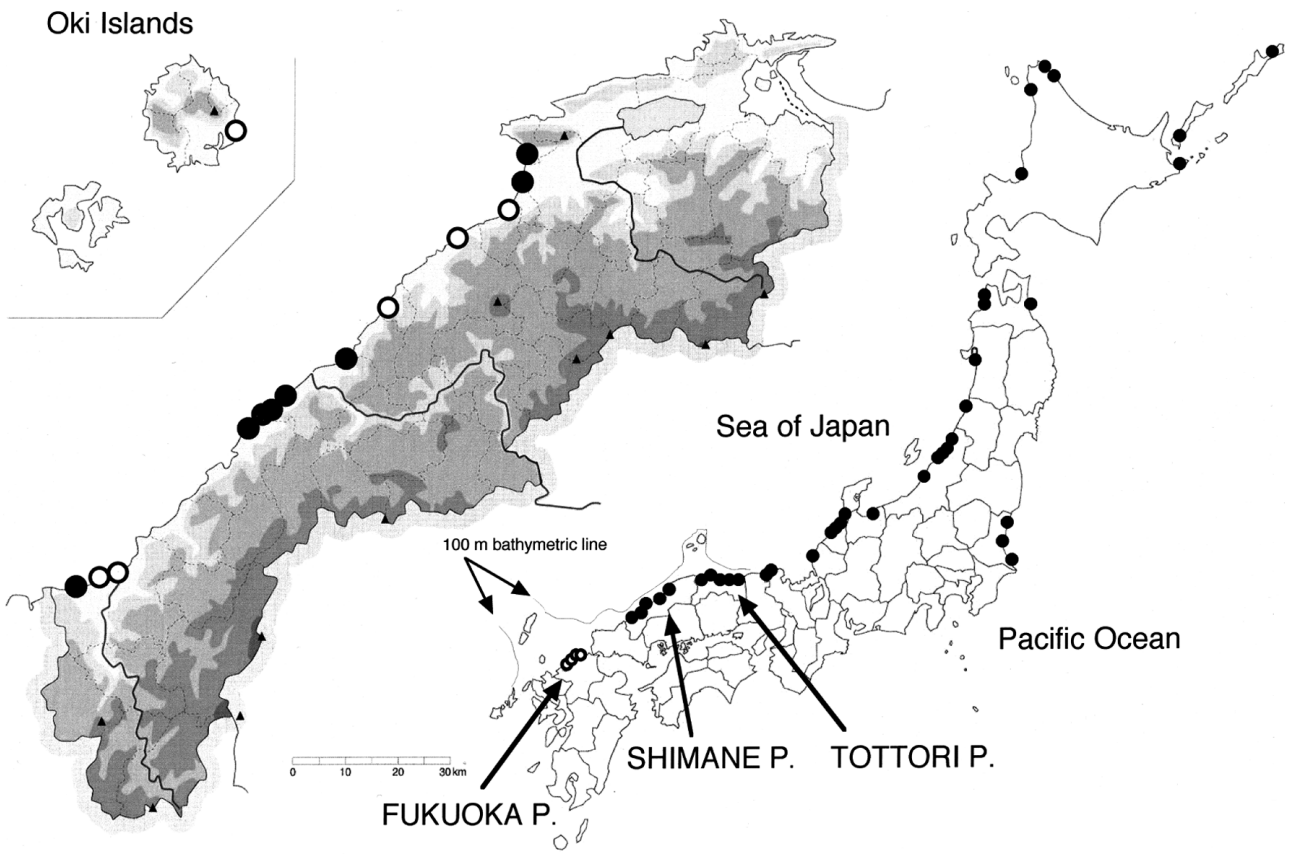

Fig. 1. Distribution of *Lycosa ishikariana* in Japanese Islands compiled from literature records (Tanaka 1978; Ono et al., 1991; Inoue 1991; Yoshida 2003, etc.) and present data (right) and Shimane Prefecture (left map with a scale, in 2005). Solid circles: sites where burrows of *L. ishikariana* were found. Open circles: sites surveyed but no burrows were found. Open circles in Fukuoka Prefecture (right map) represent following four sites surveyed in June 7–8, 2006: Saitozaki and Nata in the Umi-no-Nakamichi Beach (Fukuoka City), Hatsu Beach (Okagaki-cho), and Sanri-Matsubara Beach (Okagaki-cho). Bathymetric lines of 100 m indicate shore lines at the latest glacial period ca. 17,000 to 18,000 years B. P. in northern Kyushu and the San'in Coast.

Figure 3 shows distribution of *L. ishikariana* in Tottori Sand Dunes in 2005. We surveyed all the area of Tottori Sand Dunes including a northeastern extension of the sand dunes of ca. 4 km long (Sakyu Bathing Beach) from the river-mouth of the Sendai River to that of the Yadani River at Iwado Port along shores with a distance of ca. 7.5 km. However, no burrows were found other than the plots shown in Fig. 3 in which northeastern extension was curtailed. The northeastern extension, which is completely devoid of burrows of *L. ishikariana*, has a long (ca. 4 km) sandy beach accompanied by a row of foredune. However, the beach, which is severed by a prefectural road No. 319 (Tottori Sakyu — Hosokawa Road) that stretches along the beach from other landward dunes afforested with *Pinus thunbergii* and *Robinia pseudoacacia* for erosion control, is rather narrow (shorter than 50 m in width). Recession of beach in this area is rather conspicuous for the past 20 years and the beach has recently been extensively changed due to shore protection works. Unfortunately, no mention has been made for the presence/absence of the species in this northeastern area, in the former reports on the Tottori Sand Dunes population of the species (Fukumoto 1955, 1989; Yoshida 1979).

2) Density and spatial pattern of distribution

Density of the burrows constructed by *L. ishikariana* per square meter ranged from 0.02 [Only 1 specimen found in a 50 m^2 (5 m × 10 m) area surveyed] to 0.38 at the Karo Beach, eastern part of Tottori Prefecture. No significant relationships were detected between the density and any of the environmental factors, such as sand grain size and beach area.

An analysis of spatial pattern of distribution revealed that, of a total of 11 populations where Morisita's indices were calculated, seven were "random" and four were "contagious". Population density seemed somewhat higher in populations with contagious distribution (mean with SD = 0.285 ± 0.114, n = 4) than in populations with random distribution (mean with SD = 0.185 ± 0.072, n = 7), though the difference was not statistically significant ($P = 0.184$, Mann-Whitney U-test). Paucity of the populations where more than 5 individuals were found limited the number of the data and, it made drawing any meaningful conclusion difficult.

3) Factors affecting occurrence of *Lycosa ishikariana*

a) Sand grain size and sorting index. Median sand grain

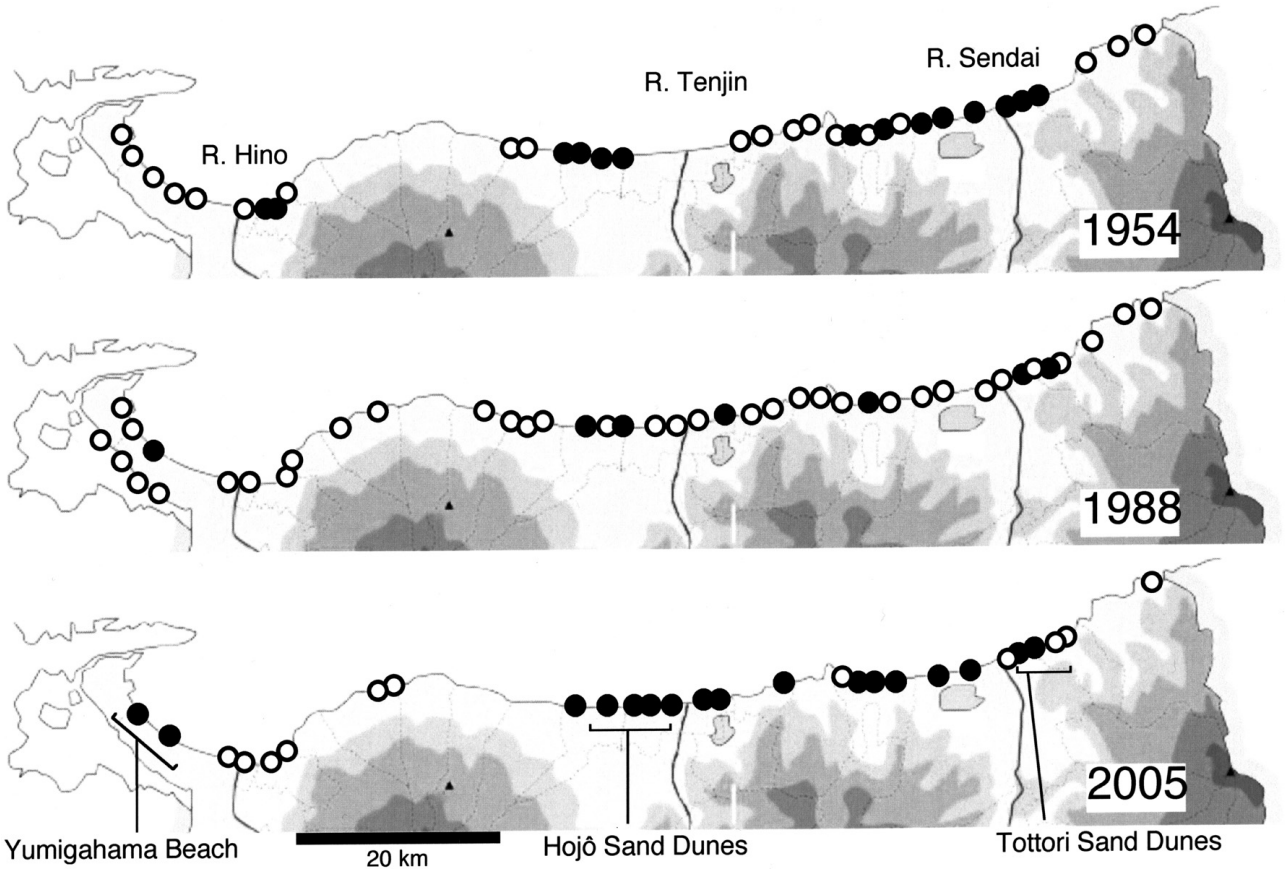

Fig. 2. Distribution of *Lycosa ishikariana* in Tottori Prefecture in 2005 (bottom) and in the past (1954 and 1988 based on Fukumoto 1989); Solid circles: sites where burrows of *L. ishikariana* were found. Open circles: sites surveyed but no burrows were found.

sizes (MSGS) of beaches widely ranged from 0.25 mm in Yatsukami Beach to 1.04 mm in Nishizono (Hôjô Sand Dunes) in the area surveyed. *Lycosa ishikariana* was found from all the beaches with median sand grain sizes larger than 0.6 mm, while in the beaches with the grain size smaller than that the frequency that the spiders were found was approximately fifty-fifty (Fig. 4). There was no significant difference between the sand grain sizes in the beaches where *L. ishikariana* resides (0.574 mm on average) and the beaches without the spiders (0.398 mm on average) (P = 0.0994, Mann-Whitney U-test). Simple logistic regression analysis, however, produced a logistic model: $P = 1/[1 + \exp\{-(1.712 - 5.257\ MSGS)\}]$ (P = 0.0308, R^2 = 0.133, n = 28), where P is the natural log of the odds of *L. ishikariana* occurring on a beach. According to the model, sand grain size (50% probability of occurrence of *L. ishikariana*) needed for the occurrence of *L. ishikariana* was estimated to be 0.326 mm.

In beaches lacking *L. ishikariana*, sorting index (SI) of sand also tended to have smaller values (Fig. 4). The difference in the sorting index between the beaches with and without *L. ishikariana* (means 0.30 and 0.23, respectively) was marginally significant (P = 0.0614, Mann-Whitney U-test) and simple logistic regression generated a significant model (P = 0.0488, R^2 = 0.122, n = 28): $P = 1/[1 + \exp\{-(1.117 - 0.0185SI)\}]$. On the other hand, sorting index was moderately correlated with median sand grain size ($SI = 0.1321 + 0.2827MSGS$, $R^2 = 0.425$, $P = 0.0002$). This means that either a sand grain size or a sorting index of the sand particles may give rise to a superficial correlation to the occurrence of the spiders, if one of the two factors would actually affect the occurrence of the spiders.

b) Length, width, and areas of beaches. *Lycosa ishikariana* tended to be found in beaches with larger areas and it was always found in beaches with an area larger than 10,000 m^2 (7 beaches: Table 1). Simple logistic regression was performed on the presence/absence of *L. ishikariana* to $\log_{10}$ transformed beach area ($\log_{10}$BA). The model obtained with high significance (P = 0.0002) was: $P = 1/[1 + \exp(7.210 - 4.794\ \log_{10}BA)]$ ($R^2 = 0.423$, n = 24). According to the model, beach area with a 50% probability of occurrence of *L. ishikariana* was estimated to be 0.0313 km^2.

Both the length and width of beach also generated statistically significant models when simple logistic regression was conducted between each of them and the presence/absence of *L. ishikariana* (P = 0.0205 for beach length, P = 0.0214 for beach width: both for $\log_{10}$ transformed data and n = 24) and the 50% probability of occurrence of *L.*

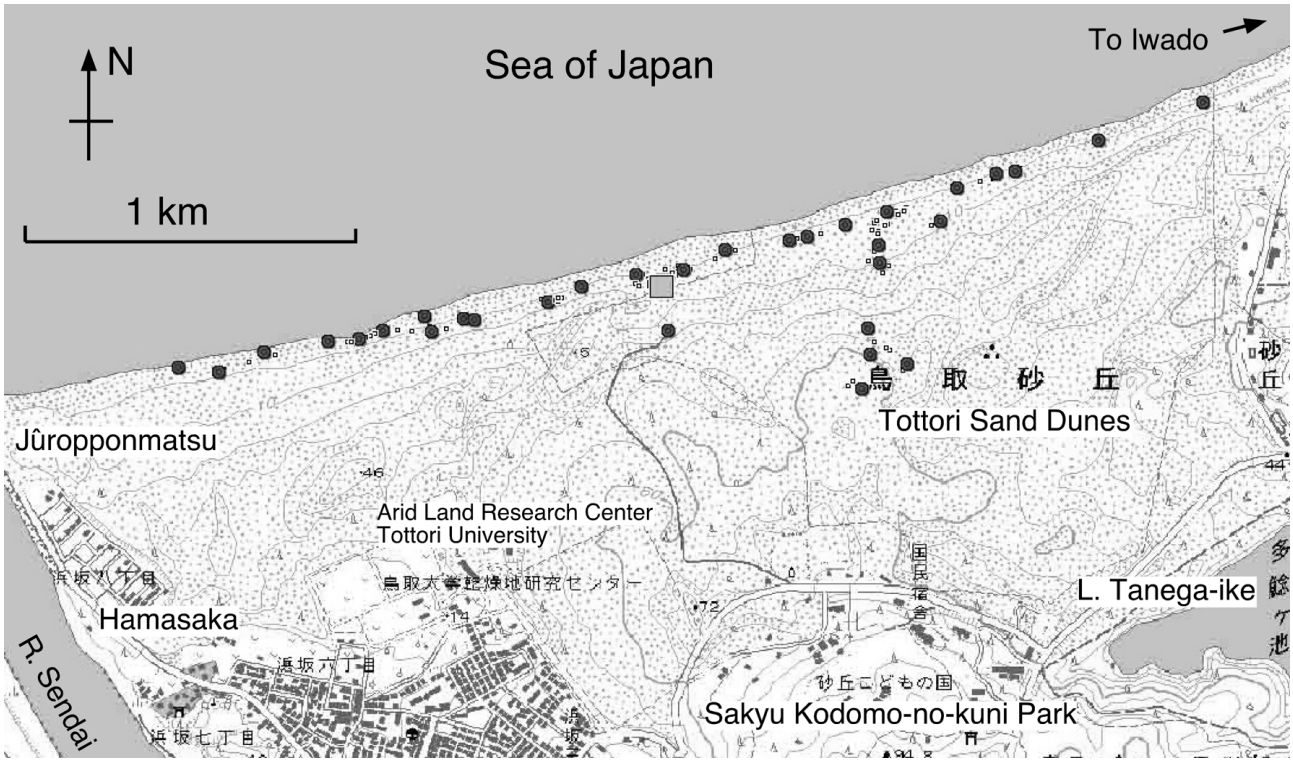

Fig. 3. Distribution of burrows of *Lycosa ishikariana* in Tottori Sand Dunes in 2005 depicted from GPS data by using Kashimir 3D ver. 8.6 (Sugimoto, 2005) on the 1/50,000 scale map "Tottori-Hokubu" issued by Geographical Survey Institute, Japan. All the coast of ca. 7.5 km long from the rivermouth of the Sendai River to that of the Yadani River at Iwado was surveyed, but burrows were found only at sites (solid circles) shown on the map. A solid square in the middle represents a site periodically surveyed.

ishikariana was estimated to be 0.985 km long and 59.7 m wide. Width of beach seemed more critical than beach length for the occurrence of *L. ishikariana*, because the species was also found in beaches with smaller areas if width of the beach is enough, as exemplified in Uno Beach (No. 11 in Table 1), Hawai Rinkai Park (No. 12), Iwami Beach Campground (Hamada City, No. 36), and so on.

c) Relative importance of factors. We performed multiple logistic regression analysis to examine relative importance of five variables (sand grain size, sorting index of sand grain, length of beach, width of beach, and beach area) in relation to probability of the occurrence of a population of *L. ishikariana* based on 24 different beaches where data of all the five variables are available (beaches marked with an asterisk in Table 1). By eliminating variables with the probability more than 0.2 in the likelihood test, beach area ($P=0.0003$) and median sand grain size ($P=0.122$) were selected as important explanatory variables. Probability of the occurrence of a population of *L. ishikariana* was expressed as follows:

$$P=1/[1+\exp\{-(-5.759-10.300\ \log_{10}BA-6.569MSGS)\}](R^2=0.498)$$

The result suggests that the probability of the occurrence of *L. ishikariana* increases with increasing beach area and increasing sand grain size. Sand grain size tends to be larger when beaches are exposed to wave action and slope of beach face is steep (Brown & McLachlan 1990). The result corroborates empirical inference that *L. ishikariana* tends to be found in large sandy beach facing to open sea (Tokumoto 2000a, 2004, 2005; Yoshida 2003)

4) Probable absence *of Lycosa ishikariana* in sandy beaches in northern Kyushu

Confirmation of the abundant occurrence of *L. ishikariana* in the westernmost beaches in Shimane Prefecture obliged us to conceive that the species might be also distributed in the San'in Coast of Yamaguchi Prefecture, westernmost Honshu. However, the area is devoid of sandy beaches with a considerable magnitude necessary for the occurrence of the species. Thus, the odds that populations of *L. ishikariana* are found in this area seem to be rather slim (Mr. Naotake Inoue has visited sandy beaches in Hagi City to find *L. ishikariana* but failed it: N. Inoue, pers. comm.).

In contrast to the San'in Coast of Yamaguchi Prefecture, there are well-developed sandy beaches along the northern coast of Kyushu (Fukuoka Prefecture). Keeping these in mind, we made an additional survey of distribution of the species on June 7–8, 2006 in the following sandy beaches of Fukuoka Prefecture: (1) Ôdake-Matsubara Beach, Saitozaki, Fukuoka City; (2) Nata Beach, Shibu Shrine, Fukuoka City;

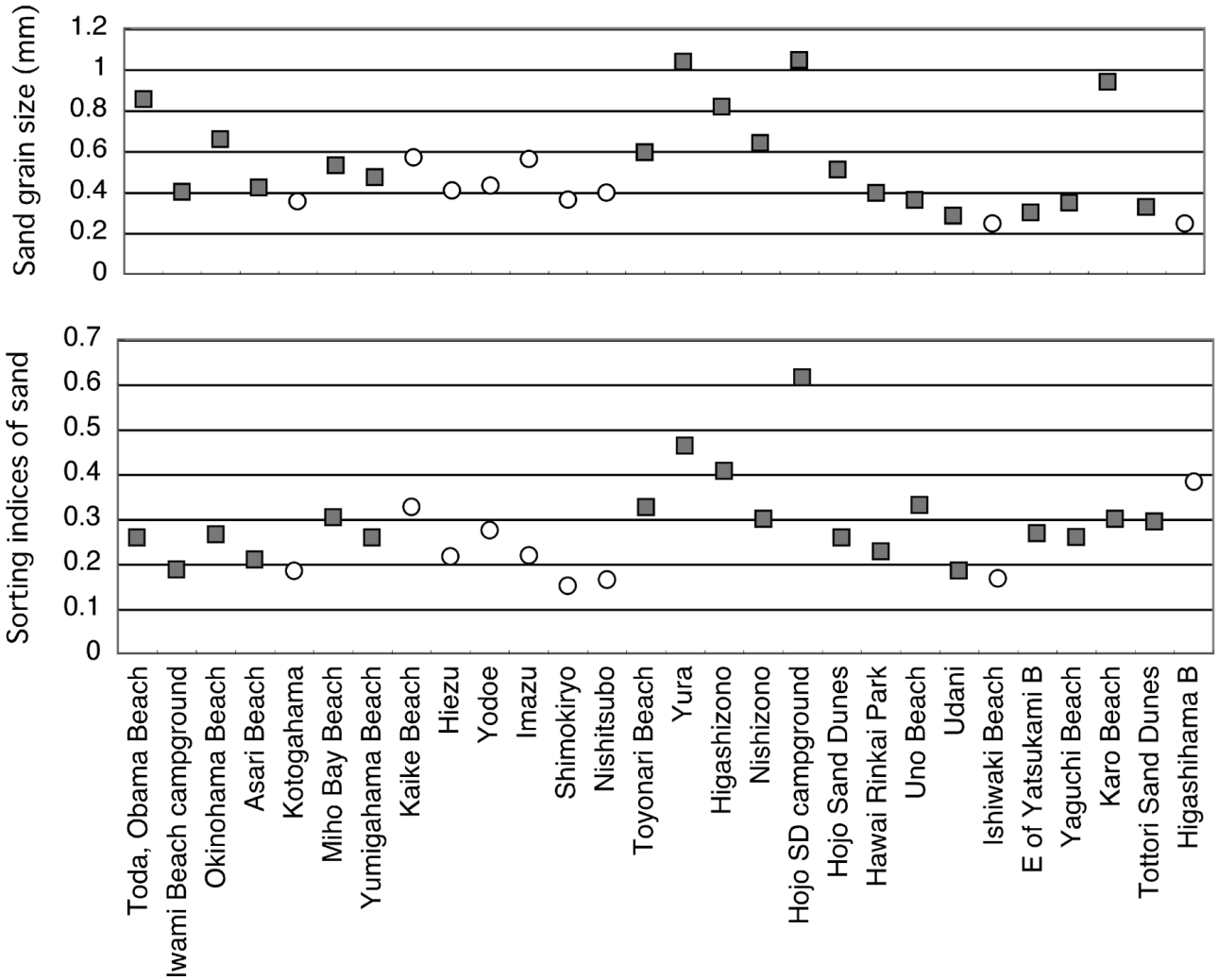

Fig. 4. Median sand grain size (top) and sorting indices of the sand (bottom) in 28 coastal sites serially arranged from west to east in Shimane (from Toda to Kotogahama beaches) and Tottori Prefecture (from Miho Bay to Higashihama beaches). Solid squares and open circles represent sites where *Lycosa ishikariana* was found and not found, respectively.

(3) Sanri-Matsubara Beach (Okagaki-cho); (4) Hatsu Beach (Okagaki-cho). These sandy beaches have a long coastline and foredunes associated with creeping grasses and succulent herbs such as *Carex kobomugi* (Cyreraceae), *Calystegia soldanella* (Convolvulaceae), *Vitex rotundifolia* (Verbenaceae), and seemed to have conditions suitable for the occurrence of *L. ishikariana*. However, any signs of the spider's occurrence were not found in those beaches.

These beaches in northern Kyushu are located in the area where a land bridge (100 bathymetric lines) that connected the Korean Peninsula and the Japanese Islands with Tsushima as a relay island existed during the last glacial period (ca. 17,000−18,000 years B.P.). An area flanked by two bathymetric lines shown in Fig. 1 corresponds to the land bridge envisaged. It is unlikely that *L. ishikariana* having a boreal distribution along the Sea of Japan, extended its distributional range southward to the newly formed sandy beaches in the northern coast of Kyushu Islands after the disappearance of the land bridge and intrusion of the warm Tsushima Current into the Sea of Japan. Hence, lacks of *L. ishikariana* in these beaches may be ascribed not to the recent extinction of the populations of the species but to the absence of the species in the areas from the beginning.

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Table 1. Beaches surveyed in Tottori (Nos. 1–25) and Shimane (Nos. 26–39) in 2005.

No.	Locality[1)]	Date	No. of specimens	Density No. indiv./m^2	Spatial distribution[2)]	Median Grain size MD_ϕ (mm)	Sorting Index σ_I	Beach[3)] Lengh (km)	Area (km^2)	Width (m)
1	Higashihama, Iwami-Cho*	13-Jun	Absent	—	—	0.247	0.384	1.63	0.082	75
2	Tottori SD*	13-Jun	8	0.16	R	0.327	0.294	3.50	1.964	1250
3	Karo B, Tottori City*	14-Jun	19	0.38	C	0.938	0.300	1.38	0.055	62.5
4	Suetsune, Tottori City	14-Jun	5	0.1	—	—	—	1.50	0.082	50
5	Yaguchi B, Tottori City*	14-Jun	1	0.02	—	0.347	0.259	1.43	0.064	150
6	Hamamura B, Tottori City*	8-Jun	10	0.2	—	0.299	0.268	1.68	0.082	75
7	E of Yatsukami, Tottori City	8-Jun	17	0.34	C	—	—	0.88	0.055	75
8	W of Yatsukami, Tottori City*	8-Jun	Absent	—	—	0.245	0.167	0.70	0.036	75
9	Ishiwaki B, Yurihama-Cho*	16-Jun	9	0.18	R	0.285	0.184	1.03	0.055	62.5
10	Udani, Yurihama-Cho*	16-Jun	1	0.02	—	0.360	0.330	1.00	0.073	137.5
11	Uno B, Yurihama-Cho*	16-Jun	4	0.08	—	0.394	0.227	0.88	0.018	75
12	Hawai Rinkai Park, Yurihama*	20-Jun	2	0.04	—	0.509	0.258	0.88	0.027	125
13	East of H_j_ SD, Hokuei-Cho	20-Jun	8	0.16	R	1.045	0.616	9.13[a]	0.600[a]	150[a]
14	Hôjô CG, Hokuei-Cho	20-Jun	6	0.12	C	0.638	0.300	9.13[a]	0.600[a]	150[a]
15	Higashizono, Hôjô SD*	20-Jun	2	0.04	—	0.816	0.463	9.13[a]	0.600[a]	150[a]
16	Nishizono, Hokuei-Cho	20-Jun	1	0.02	—	1.036	0.407	9.13[a]	0.600[a]	150[a]
17	Yura, Hokuei-Cho*	22-Jun	15	0.3	C	0.594	0.325	3.88	0.127	62.5
18	Toyonari Coast, Kotoura-Cho*	22-Jun	Absent	—	—	0.398	0.164	0.63	0.009	25
19	Nishitsubo, Kotoura-Cho*	22-Jun	Absent	—	—	0.363	0.152	0.38	0.009	47.5
20	Imazu, Daisen-Cho*	22-Jun	Absent	—	—	0.561	0.218	0.75	0.009	47.5
21	Yodoe, Daisen-Cho*	22-Jun	Absent	—	—	0.432	0.275	0.88	0.018	25
22	East of Hino River, Hiezu*	27-Jun	Absent	—	—	0.409	0.217	1.00	0.027	75
23	Kaike B, Yonago*	27-Jun	Absent	—	—	0.569	0.327	3.78	0.018	175
24	Yumigahama B, P*	27-Jun	4	0.08	R	0.473	0.258	8.88[b]	0.345[b]	75[b]
25	Miho Bay P, Yumigahama B	27-Jun	1	0.02	—	0.529	0.304	8.88[b]	0.345[b]	75[b]
26	Shiohama B, Dôgo Is, Oki	12-July	Absent	—	—	—	—	0.150	0.005	30
27	Inasa B, Izumo City	9-Sept	2	No data taken	—	—	—	1.50	0.057	38
28	Kunibiki B, Koryô-Cho	6-Jun	1	0.02	—	—	—	4.45	0.164	87.5
29	KiraraTaki P, Taki-Cho	6-Jun	Absent	—	—	—	—	1.00	0.040	40
30	Minato B, Oda City	6-Jun	Absent	—	—	—	—	0.50	0.013	25
31	Kotogahama B, Nima, Oda*	7-Jun	Absent	—	—	0.356	0.184	1.50	0.027	87.5
32	Asari Beach, Gôtsu*	7-Jun	16	0.32	R	0.421	0.209	2.68	0.155	225
33	Okinohama B, Gôtsu*	7-Jun	Numerous	No data taken	—	0.656	0.265	4.70	0.345	137.5
34	Iwami B, Aquas (2), Hamada	6-Jun	10	0.2	R	—	—	3.50[c]	0.227[c]	112.5[c]
35	Iwami B, Aquas (1), Hamada	6-Jun	10	0.2	R	—	—	3.50[c]	0.227[c]	112.5[c]
36	Iwami B, CB, Hamada*	7-Jun	1	No data taken	—	0.400	0.186	0.85	0.027	50
37	Nakasu CG, B, Masuda	7-Jun	Absent	—	—	—	—	1.55	0.093	60
38	Sanrigahama B, Masuda	7-Jun	Absent	—	—	—	—	2.25	0.090	50
39	Toda B, Masuda*	7-Jun	1	0.02	—	0.853	0.258	2.00	0.136	100

1) B＝Beach, SD＝Sand Dunes, CG＝campground, P＝Parking, Localities asterisked are used for multiple logistic regression analysis.
2) Type of the spatial distribution was judged by using Morisita's index for only sites more than 5 burrows were found. Type of spatial distribution: R＝random, C＝contagious. (I_δ and *F*-test)
3) Localities sharing the same superscript letter are on the continuous stretch of a beach.

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